GLAST Front End Processor (GFEP)

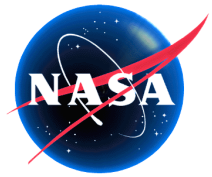
Peer Review

February 12, 2004

Howard Dew
Lead Ground System Engineer
Systems Integration and Engineering Branch
GSFC Code 581.0

Ross Cox
Ground System Engineer
ASRC Aerospace Corporation

GFEP Peer Review Agenda



- Introduction
  - Purpose
  - Mission Overview
- System Architecture
  - External Interfaces
  - GFEP Internal Interfaces
- Key Requirements
  - Documentation
- Development Methodology
  - Development Approach
  - Implementation Approach
  - Testing Approach
  - Maintenance Approach
  - Configuration Management
  - Risk Management
- Operations Concept
  - Normal Operations
  - Contingency Operation
  - Pre-Launch
  - Launch and Early Orbit
  - Mission
- Programmatics
  - Development Schedule
  - Cost
- Open Items
- Road to SDR

Introduction

Howard Dew

Lead Ground System Engineer

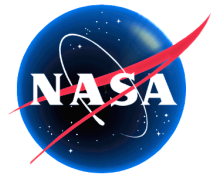
Systems Integration and Engineering Branch

GSFC Code 581.0

Purpose

- ***Present Overview Ku-band Operations***
- ***Review Key Requirements***
- ***Verify methodology used for development, test and maintenance***
- ***Panel of Peers***
  - *Chairs*
  - *Security*
  - *WSC*
  - *Networks*
  - *Ground System*
- ***Other Stakeholders***
  - *MOC Contractor*
  - *GLAST Systems Engineers*
  - *I&T Engineers*

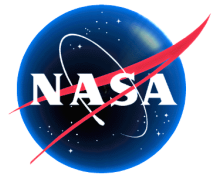
Purpose



- ***Panel's Charter Is To Assure Operability Of Presented Design And Provide Third Party Perspective***
  - *Useful Suggestions*
  - *Constructive Commentary*
  - *Other Mission Experience And Lessons Learned*

- ***Requests For Action (RFAs) Generated With Panel Member Sponsorship.***

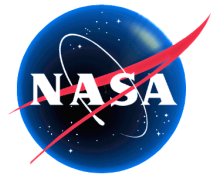
Purpose RFA Form



Request For Action	RFA Number:
RFA Date:	
Project:	GLAST
System:	GLAST Front End Processor
Review:	GFEP Peer Review
Review Date:	February 12, 2004
Originator:	
Discrepancy/ Problem:	
Recommended Action:	
Assignee:	
RFA Response:	

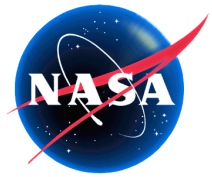
- *Date Written*
- *Brief Description*
- *Suggested Corrective Action*
- *Assigned by GSOM*
- *Completed by Assignee*

Mission Overview A Gamma - Ray Astronomy Mission



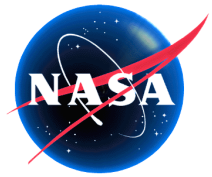
- ***Follow-on/Extension Of CGRO Instruments***
  - *LAT - Large Area Telescope*
    - *Stanford Linear Accelerator Center*
  - *GBM – GLAST Burst Monitor*
    - *National Space Science and Technology Center (NSSTC)*
  - *Integration By Spectrum Astro Inc*
- ***5 Yr Mission Life With 10 Year Goal***
  - *1st Year Full Sky Survey*
- ***Nominal 565 Km Altitude (96 Min Period), 28.5 Degree Inclined Circular Orbit***
  - *No Orbit Maintenance*
  - *Controlled Re-entry At End Of Life*
- ***Current Launch Date – February 2007***

Mission Overview Brief History



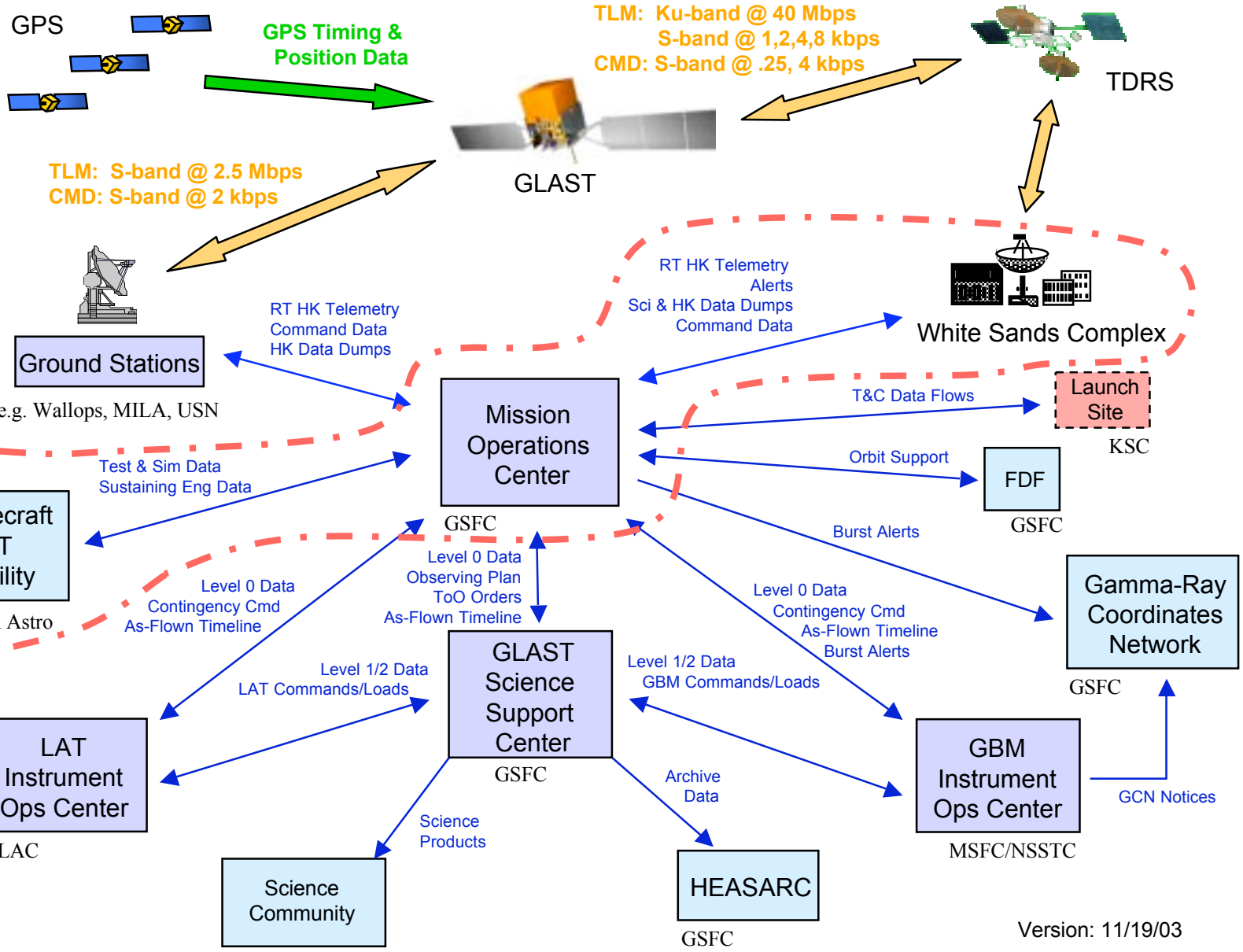
- ***Mission Originally Planned For X-band At 150 Mbps***
  - *"Free" Malindi Support In Exchange For Mirror Data Center*
  - *One Dump Required Per Day For 312 Kbps Science Data Rate*
    - *Two Per Day Were Planned Nominally*
    - *Contributed To 36 Hour Latency*
- ***Mission Changes***
  - *Malindi Became Unfunded For GLAST*
    - *Return From Site Was Questionable Anyway*
  - *Spectrum Allocation Was Only Available For 20 Mbps (Required Waiver)*
- ***Project Undertook Study Which Resulted In Ku-band Mission***

Mission Overview Mission Features



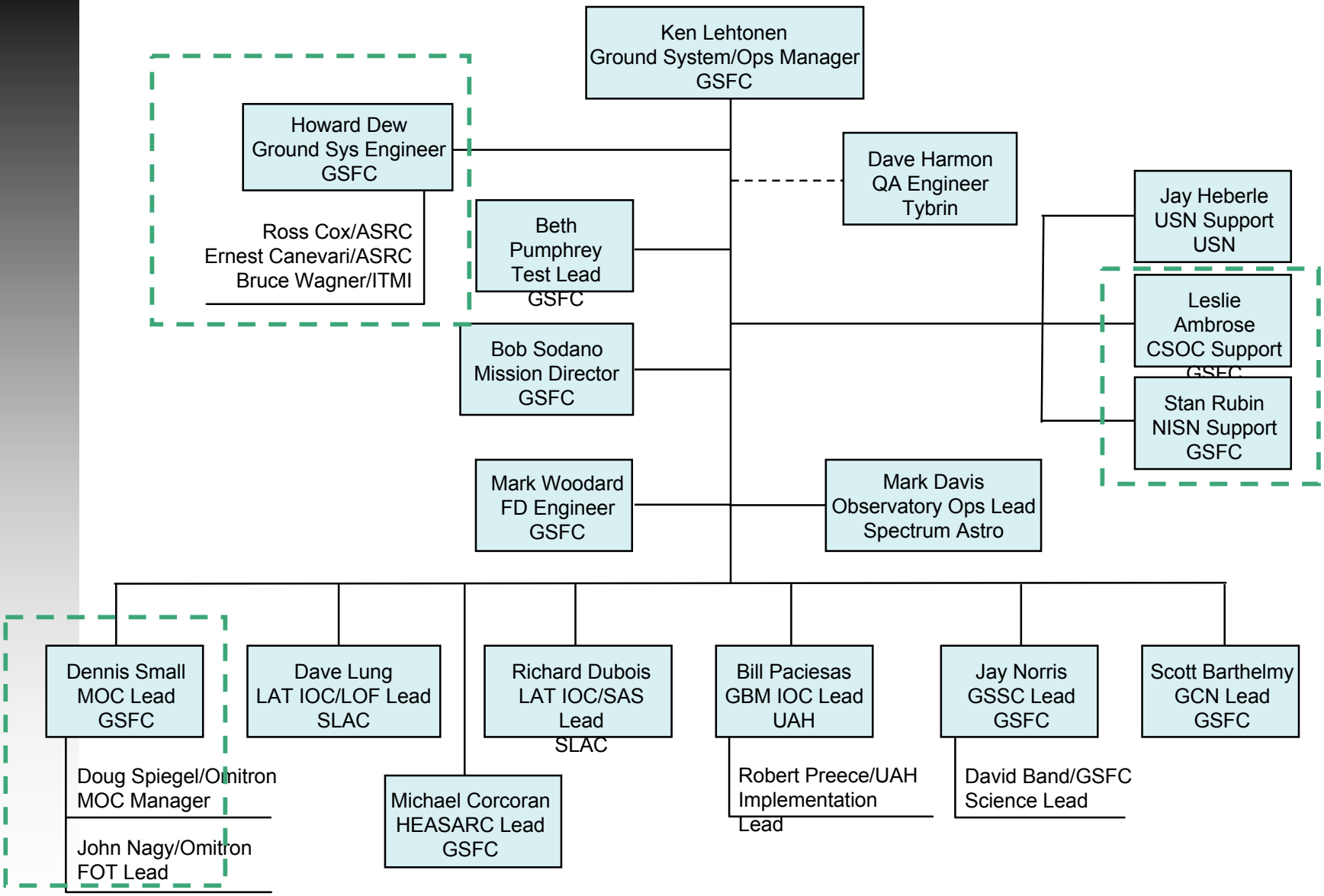
- ***Both Instruments Can Process Burst Alerts To Be Delivered From Space To User Interface In Approximately 7 Seconds***
  - *CCR Pending May Raise This Value*
- ***Science Data Has Latency Of 72 Hours***
  - *36 Hours Onboard*
  - *12 Hours Ground Transport Of Level 0*
  - *24 Hours To Generate Level 1 At Instrument Ops Centers*
  - *Latencies Being Revised Based On Ku Operations*
- ***MOC Will Only Be Staffed On An 8 By 5 Basis For Normal Ops***
  - *Automated Data Support*
  - *Multi-day Stored Commands*
  - *Long Range TDRS Scheduling*
  - *Off Shift Paging For Data And Spacecraft Anomalies*
  - *Web-based Status Trends*

Mission Overview Ground System Architecture

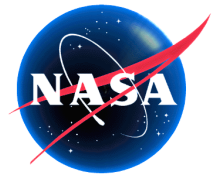


Version: 11/19/03

Mission Overview Ground System Organization

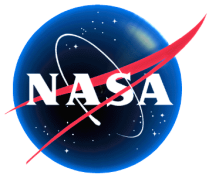


Mission Overview Organizational Interfaces



- **GFEP External Interface Organizations**
  - White Sands Complex (Code 451)
  - Nascom (Code 291)
  - Security (Code 297)
  - I&T Facility (Spectrum Astro, Inc.)
  - PSS (Code 583)

Mission Overview Data Supported



The GFEP Supports Ku-band Return Data ONLY:

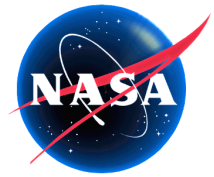
- LAT And GBM Science Recorder Dumps
  - 34.9 Mbps On VC 8 And 9
- Observatory Housekeeping Recorder Dumps
  - 5 Mbps On VC 3
- Real Time Housekeeping Telemetry
  - 51 Kbps On VC0
- Real Time Burst Alerts And Diagnostic Data
  - 1 Kbps For Burst Alerts On VC1
  - ~49 Diagnostic Kbps On VC1
- Observatory Stored RAM Dumps
  - 5 Mbps (Instead Of Observatory HK Recorder Dumps) On VC2
- Fill Frames
  - On VC63

The GFEP Does NOT Support:

- S-Band
  - Commanding
  - Non-contact Burst Alerts Or Safehold Telemetry
    - Via DAS(MA) On VC 11
  - "Low Rate" Real Time Observatory Housekeeping Telemetry
    - 1 Kbps Via MA Return On VC10
    - 4 Kbps Via SSA Return On VC10
  - "Low Rate", I.E., 2.5 Mbps Observatory Housekeeping Recorder Dumps

Mission Overview Why GFEP?

- **GLAST Mission Requirements Include:**
  - Reed Solomon Decoding
  - On-site VC Splitting
    - Separation Of Low Rate RT Channels From High Rate Stream
  - Storage For 7 Days
  - Autonomous System For Support GLAST 8x5 MOC Ops
- **Project Independence From Other Missions**
- **Desire For Passive Interface To WSC**



System Architecture

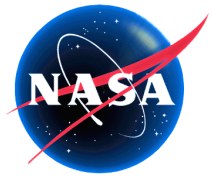
Howard Dew

Lead Ground System Engineer

Systems Integration and Engineering Branch

GSFC Code 581.0

System Architecture

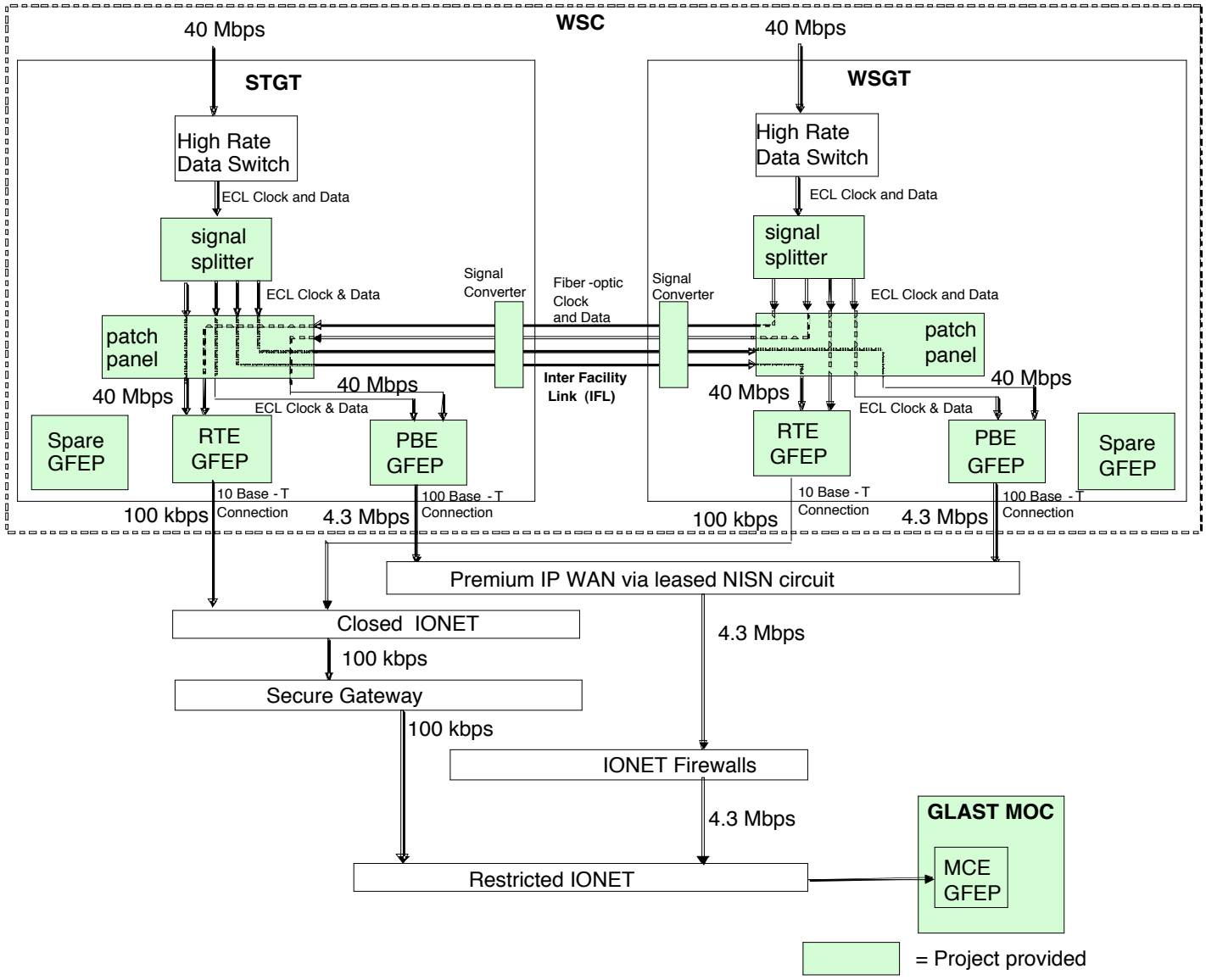


Terminology

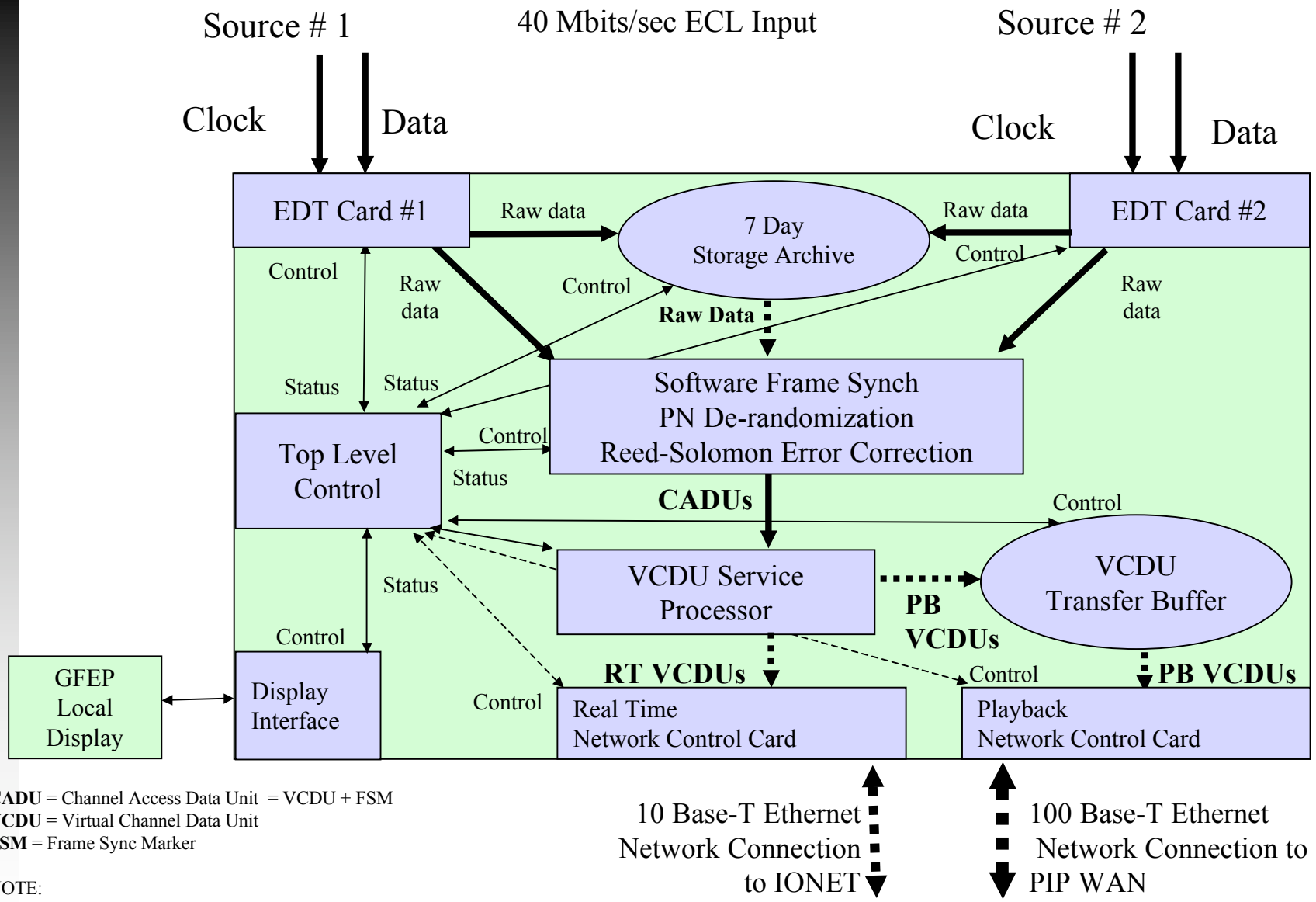
- GFEP – GLAST Front End Processor
  - The System Used To Handle The Glast-specific 40 Mbps Downlink Stream
- RTE – Real Time Element
  - Element Of The GFEP That Handles The Real Time Sub-streams
  - Located At WSC
- PBE – Play Back Element
  - Element Of The GFEP That Handles The Recorder Playback(non-real Time) Sub-streams
  - Located At WSC
- MCE - MOC Control Element
  - Element Of The GFEP That Provides For Status And Control Of The Rtes And Pbes
  - Located In The MOC

System Architecture

GLAST Ku-band Front End Architecture With Ground Terminal Cross -Strapped Redundancy



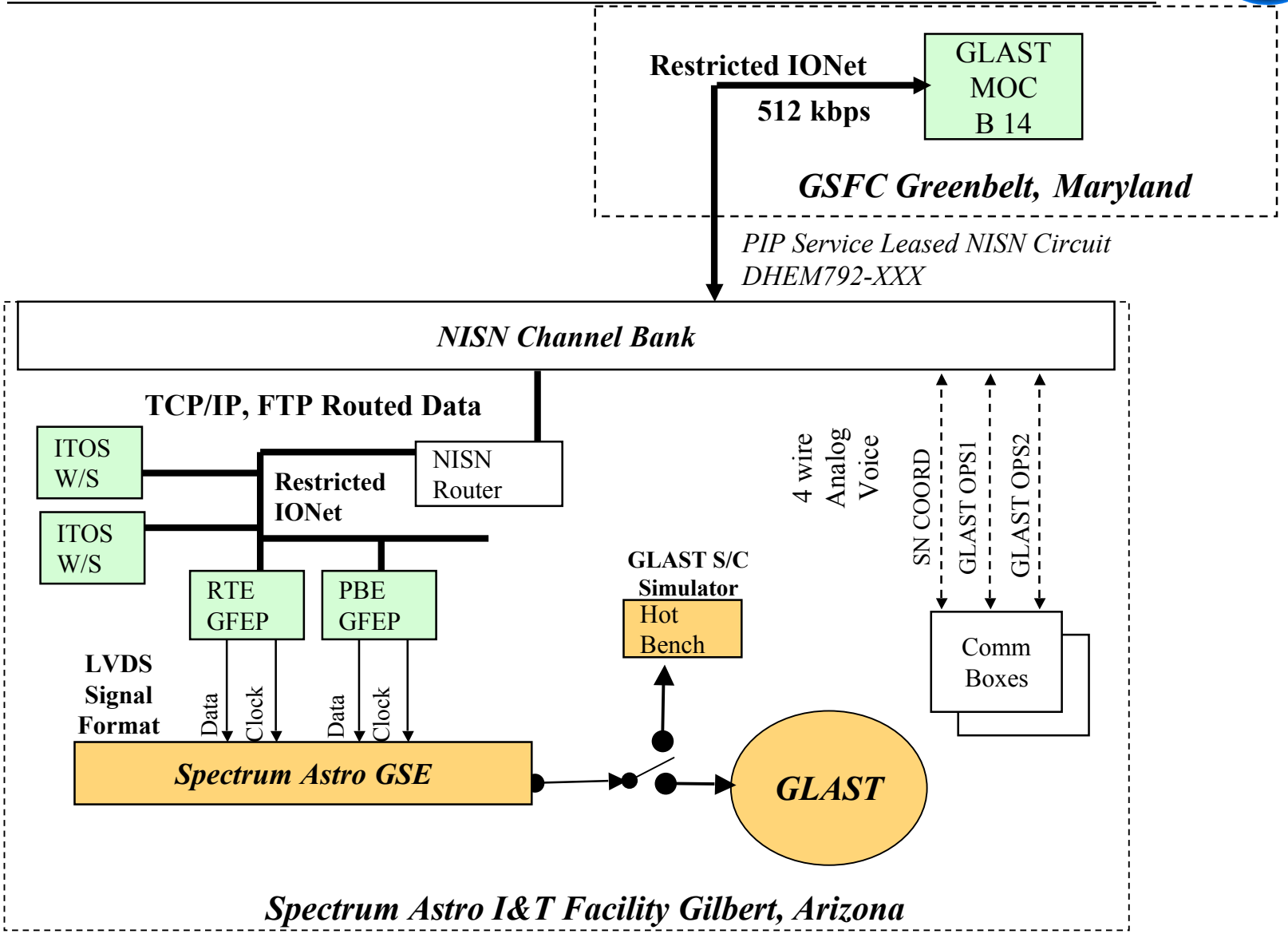
System Architecture Individual Element



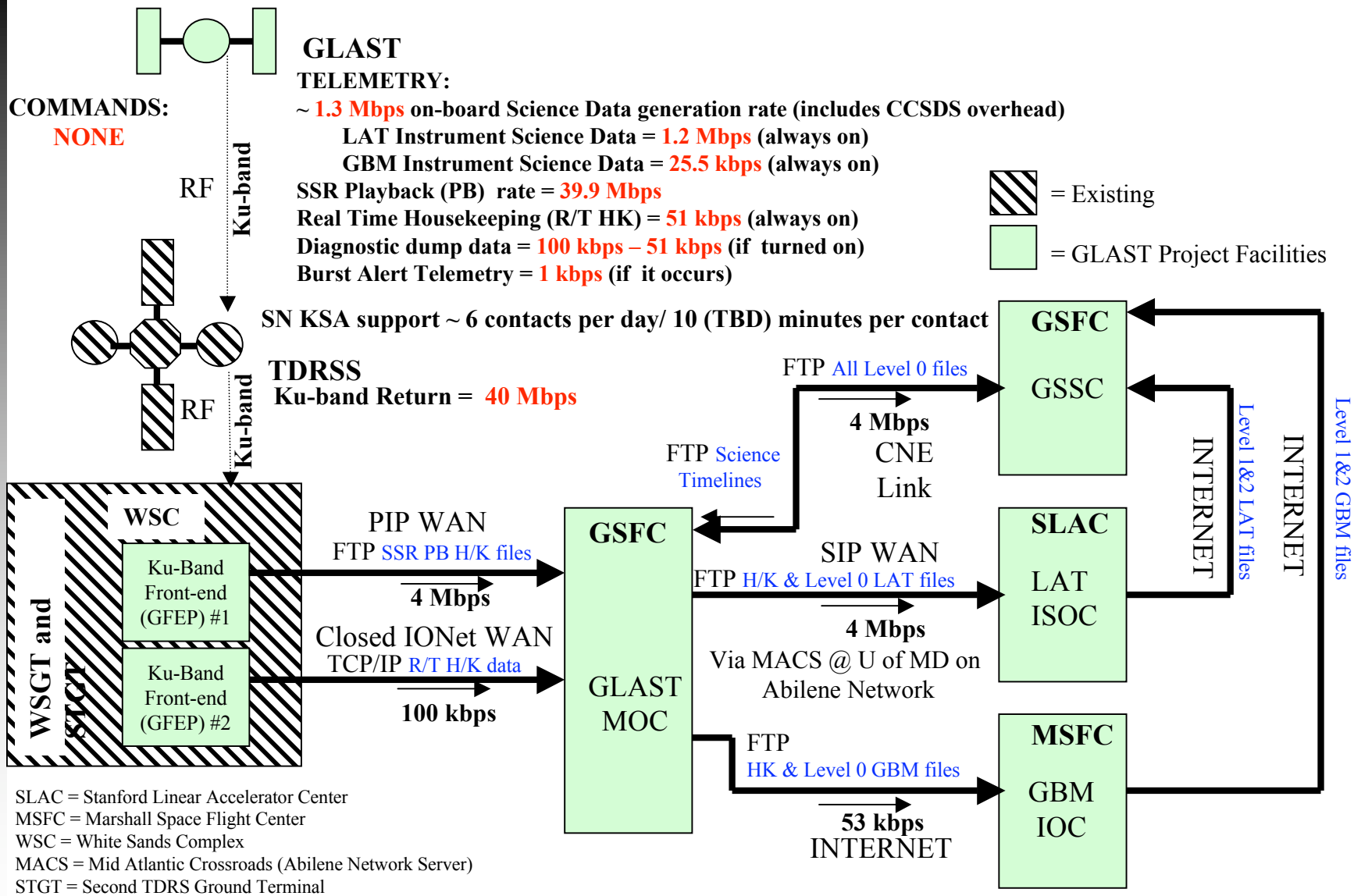
CADU = Channel Access Data Unit = VCDU + FSM
VCDU = Virtual Channel Data Unit
FSM = Frame Sync Marker

NOTE:
DOTTED LINES CONFIGURATION AND /OR CONNECTION IS DEPENDENT ON TYPE OF GFEP - RTE OR PBE

System Architecture I&T Config

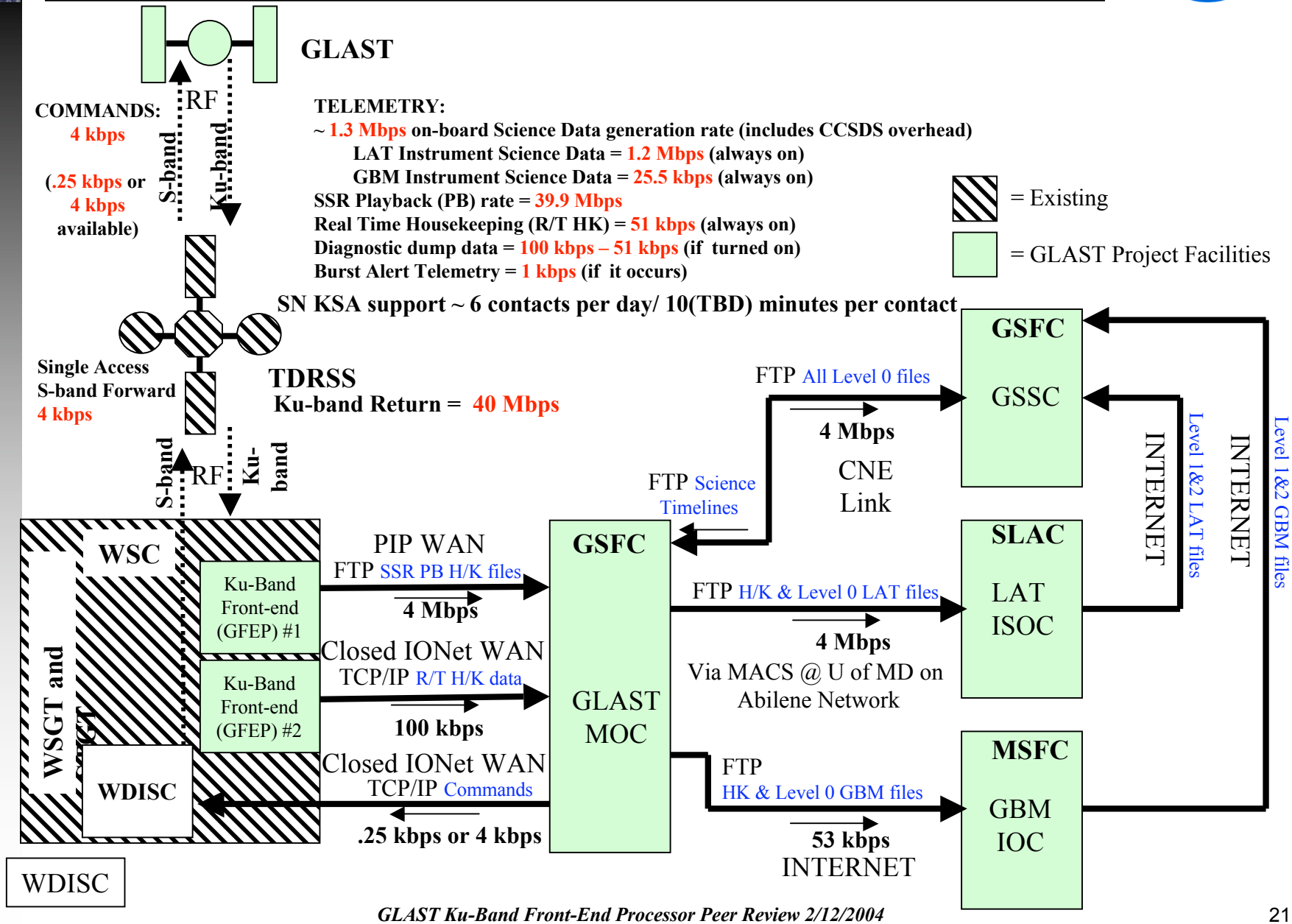


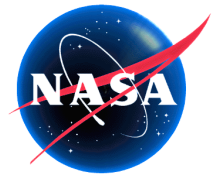
System Architecture Ku-Band Data Flow Diagram



SLAC = Stanford Linear Accelerator Center
MSFC = Marshall Space Flight Center
WSC = White Sands Complex
MACS = Mid Atlantic Crossroads (Abilene Network Server)
STGT = Second TDRS Ground Terminal
WSGT = White Sands Ground Terminal
GFEP = GLAST Front-End Processor

System Architecture Normal Pass Data Flow





Key Requirements

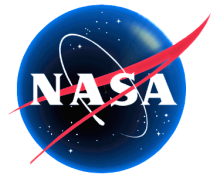
Howard Dew

Lead Ground System Engineer

Systems Integration and Engineering Branch

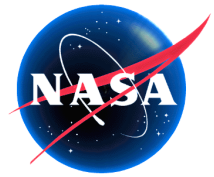
GSFC Code 581.0

GFEP Requirements Document Sections



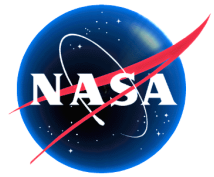
- **System**
  - System Functional
  - System Performance
  - System RMA
- **Element**
  - GFEP to Network Interface Functional
  - GFEP to MOC Functional
  - GFEP to WSC Functional
  - GFEP to WSC Performance

Key Requirements Overview



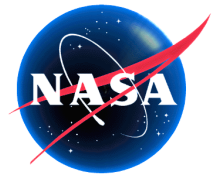
- **Data Handling**
  - *Real Time Processing Of Housekeeping Data*
  - *Post-pass Playback Of On-board Recorded Data*
- **Autonomy**
  - *No WSC Intervention Required For Normal Operations*
  - *Remotely Configurable From MOC*
  - *Support Unattended MOC Operations*
    - *MOC Staffed 8 By 5*
- **Storage**
  - *Seven Day Storage Of All Received Data*
  - *Retransmission Capability Of Stored Data*
- **Redundancy**
  - *No Single Points Of Failure*
- **Security**
  - *Compliance With Established Conventions*

Key Requirements Data Handling



- ***SYSF0230 - Perform Frame Synchronization***
- ***SYSF0260 - Perform RS Decoding***
- ***SYSF 0030 - Detect And Remove Asynchronus Synchronization Markers (ASM) From Data Stream***
- ***SYSF0170 - Support The Transmission Of The Recorded Playback Data To The MOC Post- Pass***
- ***SPER0020 - Must Record Entire 40 Mbps Stream***
- ***SPER120 - Must Support Real Time, Playback And Burst Data Flows***

Key Requirements Autonomy

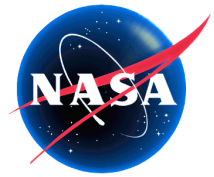


- ***SYSF0050 - Provide The Capability To Support Operations 24 Hours Per Day, 7 Days Per Week On A Continuous Basis For The Life Of The Mission***

- ***SYSF0220 - Allow For Data Transport With An Unattended MOC***

- ***SYSF0440 - Allow For Data Transport Without Wsc Intervention***

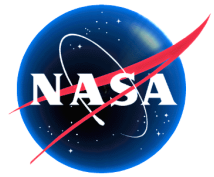
Key Requirements Storage



- ***SYSF0050 - Provide The Capability To Store On-line All Received Data For A Minimum Of 7 Days.***

- ***SYSF0180 - Support A Retransmission Request For Any Virtual Channel File To The MOC***

Key Requirements Redundancy

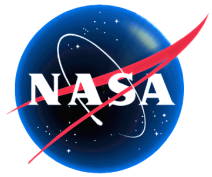


- ***SYSF0040 - Have No Single Point Of Failure That Impacts The Ability Of The System To Receive, Process, Store, Retrieve, And Transfer Real-time Mission Data***

- ***SYSF0200 - Provide The Capability To Process Data Received On Backup Data Paths Upon Determination Of Failure Of The Primary Data Path***

- ***WIFF0070 - Failovers Not Dependent On WSC Personnel***

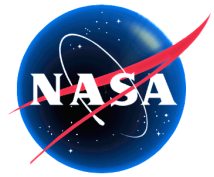
Key Requirements Security



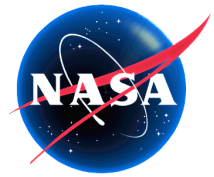
- ***SYSF0100 - Assure Compliance With NPG 2810.1***
  - *Risk Management*
  - *Contingency Plan*
  - *IT Security Plan*

- ***SYSF0120 - Assure Compliance With Closed Ionet Checklist***

Required Documentation



- **GFEP Documentation**
  - *ICD Between GFEP And MOC*
  - *ICD Between GFEP And WSC*
  - *GFEP Functional And Performance Specification*
  - *GFEP User's Guide*
  - *GFEP Programmer's Guide*
  - *GFEP Operations And Maintenance Manual*
  - *Design And Configuration Drawings*
  - *Ops Agreement Between GLAST And WSC*



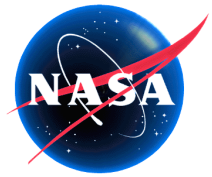
Development Methodology

Ross Cox

Ground System Engineer

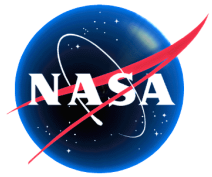
ASRC Aerospace Corporation

Development Approach



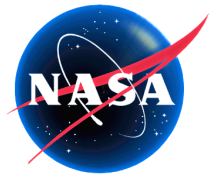
- GLAST Project Oversight
  - Hardware
    - Project Will "Own" Equipment Located At WSC
      - ASRC Will Purchase Integrate Hardware
      - Civil And ASRC Will Install All GFEPs
  - Software
    - Project Will Contract The Software Development
      - Necessary Software Interfaces Developed By PSS Developer

Implementation Approach Dev GFEP



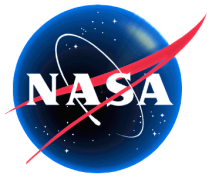
- ***Create A Stable Prototype***
  - *Used For Initial Hardware And Software Integration And Test*
  - *Emphasis On Requirements Verification*
    - *Will Perform As Either RTE Or PBE*
  - *Baseline Placed Under Formal Ground System Configuration Control*
- ***Requires Suite Of External Testing Drivers***
  - *Data Processing*
  - *Stress Testing*
- ***Kept At GSFC For Its Lifetime***
  - *Testbed For Any Changes To Baseline Configuration*
    - *Upgrades And Patches*
  - *Lifetime Expected To Be L-27(TBR) To EOM*

Implementation Approach I&T GFEP



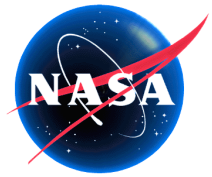
- ***"First Clone" Derived From DEV GFEP***
  - *Tested Locally At GSFC*
  - *Actually Two Machines Are Shipped*
    - *One For RTE*
    - *One For PBE*
- ***Tested At Site After Connectivity Is Established***
- ***Connects To Either Local And/Or Remote ITOS Workstation***
- ***Used For Initial RF Compat/GRT/ETE Testing***
  - *Used In Conjunction With The Compat Test Van (CTV) During RF Tests*
- ***Transported Twice During Its Lifetime***
  - *Kept At SAI From L-24 (TBR) Until Observatory Ship*
  - *Serve As On-the Shelf Spares At WSC After Observatory I&T Is Complete Until EOM*

Implementation Approach Ops GFEPs



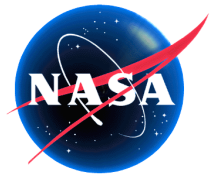
- ***"Remaining Clones" Shipped Directly To WSC***
  - *Tested Locally At GSFC*
  - *Total Of 4 Machines Are Active With 2 On-shelf Spares*
    - *On-shelf Spares May Not Be Present During Pre-launch Period*
    - *Any Particular Machine Can Be Configured As Either A RTE Or A PBE*
      - *But NOT Both Simultaneously Due To Security Connectivity Restriction*
        - » Playback Transported On Open Network
        - » Real Time Transported On Closed Network
- ***Local Post Ship Testing After Installation Complete***
  - *Piece-wise One WSC Site At A Time For Unit Functional Assurance*
  - *Full Testing For Redundancy Verification*
- ***Operationally Tested During Remaining RF Compat, GRT And ETE Tests***
  - *Timeline Would Allow GFEP Be Used During TV If 40 Mbps Is To Flowed, But Not Currently Required*
- ***Kept At WSC For Their Lifetime***
  - *L-20 To EOM*

Testing Approach



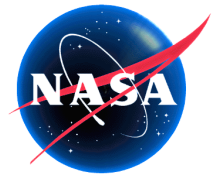
- **Proto-type Testing Environment**
  - *Non-GFEP Hardware And Software Needed To Perform Testing.*
  - *When Sufficient Testing Is Completed, Additional Machines Are Brought Into Production*
    - *Test And GFEP Systems Are Configuration Controlled.*
    - *Operational GFEP Are Produced Using The Controlled Test Environment*
- **Installation Testing**
  - *GFEPs Are Installed In The Operational Configuration At The Sites*
  - *Installation Tests Are Performed To Assure Conformity To Test Environment Results*
- **Operation Testing**
  - *Using GRT And Compat*
  - *As Described In Ground System Test Plan*

Maintenance Approach



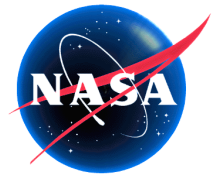
- **Hardware –**
  - Operational GFEPs Will Be Maintained By WSC
    - As Per WSC Best Practices
  - Development GFEP Will Be Maintained By MOC
    - As Per GDMS Guidelines
- **Software –**
  - FOT Responsibilities
    - Perform OS Upgrades Remotely From MOC
    - Perform Security Patches Remotely From MOC
  - GFEP Software Developer
    - Provide Patches/Upgrades As Needed

Configuration Management

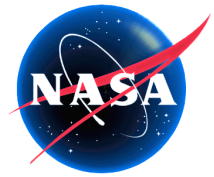


- ***The GFEP Will Comply With Same CM As Rest Of Ground System***
  - *GFEP Configuration Falls Under Jurisdiction Of The Ground System Configuration Control Board (CCB)*
    - *Chaired By GSOM*
    - *Supporting Representatives From*
      - *Project Systems Engineering*
      - *Instrument Ops Centers*
      - *GSSC*
      - *FOT*
      - *Ground System Development/Maintenance Team*
      - *Spacecraft*
      - *Others As Needed*
  - *Defined In Ground System Project Plan*

Risk Management



- ***GFEP Is Part Of Ground System/Mission Operations Risk Management Process As Described In The The Ground System Project Plan***
  - *Plan Includes Descriptions Of*
    - *Risk Identification*
    - *Risk Analysis*
    - *Risk Planning*
    - *Risk Tracking*
    - *Risk Control*
    - *Risk Elevation*
- ***Risks Get Elevated To GLAST Project Level Based On Trigger Mechanisms That Are Consistent With Triggers Used For Project Level Risks.***



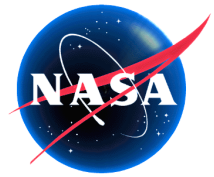
Operations Concepts

Ross Cox

Ground System Engineer

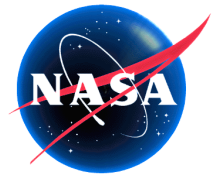
ASRC Aerospace Corporation

Operational Features



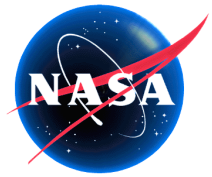
- **RTEs Boot Up And Establish Socket SessionTo MCE**
  - *Security Reasons*
  - *Each RTE Establishes Link*
    - *Don't Transmit Is Default*
  - *"I'm Okay" Signals Sent To MCE*
    - *Minutes Time Scale*
    - *Only Transmitted When Not Flowing RT Data*
  - *MOC Selects "Default" RTE To Transmit Data Over Network Resources*
    - *Prior To Each Support This Selection Can Be Changed If Necessary And/Or Advantageous*

Operational Features



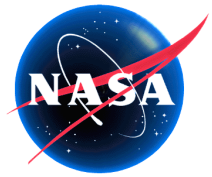
- **PBEs Boot Up Without Socket Session To MCE**
  - *Security Reasons*
  - *MCE Establishes Link To Both Pbes*
    - *PBE Boot With "Don't Transmit" As Default*
  - *I'm Okay" Signals Sent To MCE*
    - *Minutes Time Scale*
    - *Only Transmitted When Not Flowing PB Data*
  - *MOC Selects "Default" PBE To Transmit Data Over Network Resources*
    - *Prior To Each Support This Selection Can Be Change If Necessary And/Or Advantageous*

Normal Ops



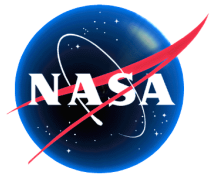
- *Pre-pass Activity*
  - *Schedule Requests Made Two Weeks In Advance Covering One Week Period*
  - *Loads Generated And Uplinked Covering One Week Period*
  - *Transmitter Comes On TBD Minutes Before A Particular Support Via Stored Command*
  - *MCE Configures/Verifies Proper GFEP Setup TBD Minutes Before Support Via Pre-pass Setup Proc*
- *Real Time Activity*
  - *Real Time Stream Flowed At AOS – Data Driven*
  - *PB Stream Commences At AOS + 1 Min Via Stored Commands*
  - *PB Stream Ceases At LOS - 1 Min Via Stored Command*
  - *Real Time Stream Ceases At End Of Scheduled Support*
- *Post Pass Activity*
  - *GFEPs Deconfigured At LOS + TBD Minutes Via Post-pass Deconfig Proc*
  - *Transmitter Turned Off At LOS + TBD Minutes Via Stored Command*
  - *PB Started At LOS + TBD Minutes Via Post Pass Deconfig Proc*

Contingency Ops



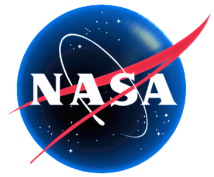
- **RTE Failure**
  - *Between Passes*
    - *Detection Of Loss Of "I'm Okay" Results In Hot Swap To Other RTE*
      - *Data Loss Volume Subject To "I'm Okay" Frequency*
      - *If Both Are Out, Ground System Pages FOT*
  - *During Pass*
    - *Loss Of Data To MOC Results In Hot Swap To Other RTE*
      - *Nominal Real Time Rate Is 51 Kbps = Very Quick Detection*
        - » Must Lose "Many" Frames Before Swap
    - *"I'm Okay" Received From "Other" RTE During Real Time*
      - *Data Loss Volume Subject To "I'm Okay" Frequency*
      - *If Both Go Out, Ground System Pages FOT*

Contingency Ops

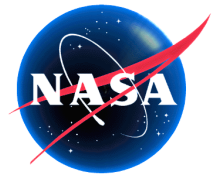


- **PBE Failure**
  - *PBE Is Not Pass Based*
    - *Playbacks Occur Independent Of Real Time Operations*
    - *Nominally These Occur Strictly Between Passes*
    - *Due To Scheduling Variability, A Playback From A Prior Pass Could Occur During A Subsequent Real Time*
  - *Whenever A PBE Fails*
    - *Detection Of Loss Of "I'm Okay" Results In Hot Swap To Other PBE*
      - *Data Loss Volume Subject To "I'm Okay" Frequency*
      - *If Both Are Out, Ground System Pages FOT*

Contingency Ops



- **Missed Pass**
  - *In The Event That A Pass Is Completely Missed*
    - *GFEPs Are Sized To Store Up To Seven Days Of Recorded Data*
    - *One Day's Worth Of Data Requires Approximately 8 Hours Of Ground Transmit Time*
      - *Recovery Of Two Additional Days Each Day Is Possible*
- **Retransmission Requests**
  - *If Data Is Lost Somewhere Down Stream Of The GFEP There Is Sufficient Capacity To Recover It*
  - *Data Is Not Archived Long Term At GFEP*
    - *After 7 Days Data Is Overwritten*



Programmatics

Howard Dew

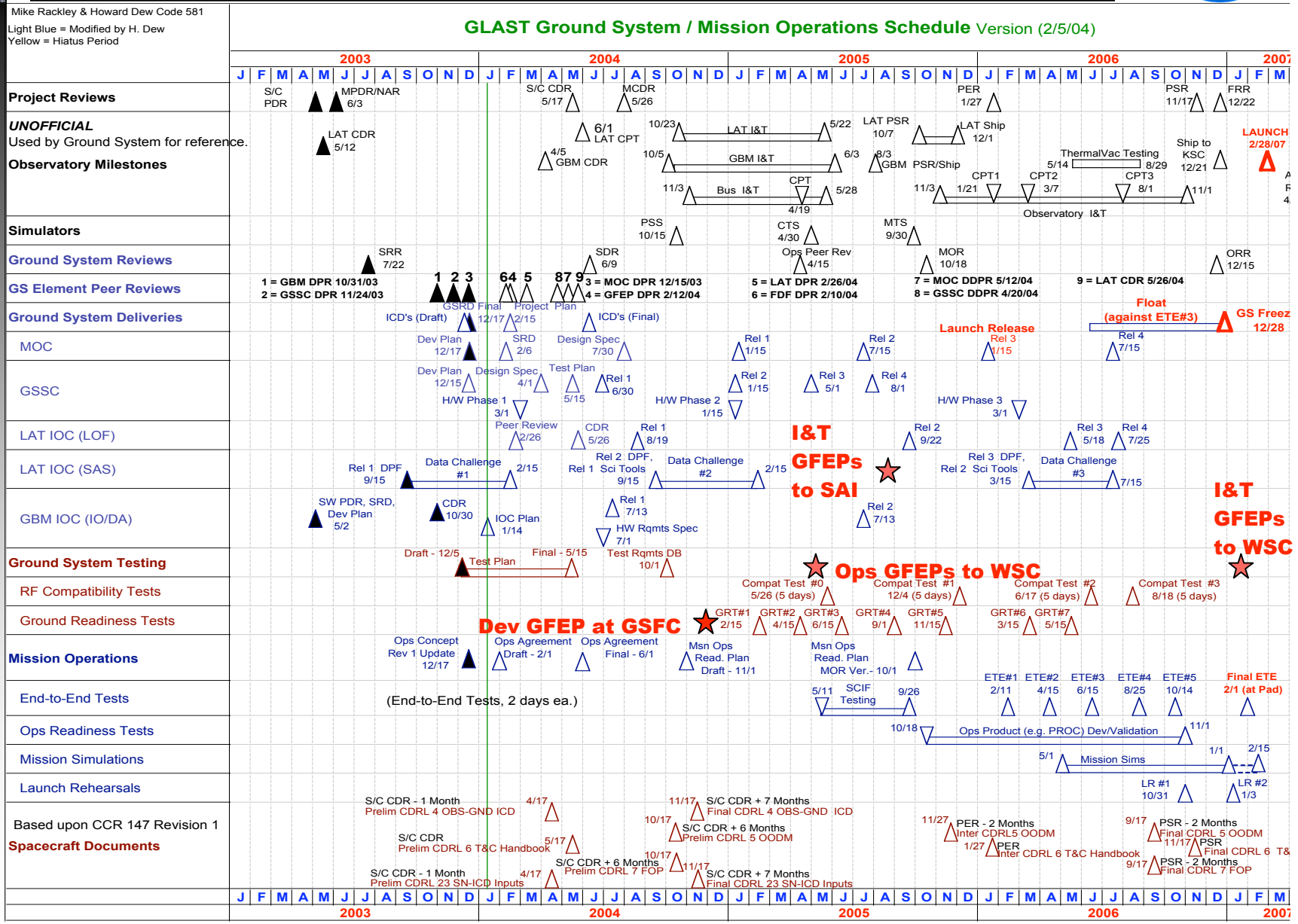
Lead Ground System Engineer

Systems Integration and Engineering Branch

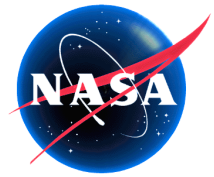
GSFC Code 581.0

Development Schedule

Mike Rackley & Howard Dew Code 581
Light Blue = Modified by H. Dew
Yellow = Hiatus Period

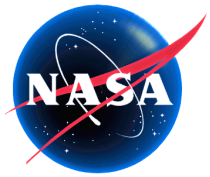


Development Schedule Drivers



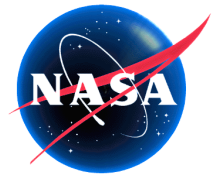
- **Development System Functional By 11/04**
  - *Begin "Cloning" Operational Units In Early '05*
- **Ops GFEP At WSC By 5/05**
  - *Needed For GRT4 In 9/05*
  - *Full-up System Not Required*
- **I&T GFEPs Operational By 8/05**
  - *3 Months Prior To Start Of Observatory I&T*
- **Full -up GFEP Configuration By 10/05**
  - *Needed Before Final MOC Release In 1/06*
  - *Full-up System For Remaining GRTs, Mission Sims And ETEs*
- **I&T Units Moved To WSC By 1/07**
  - *To Be On-shelf Spares*
  - *Assumes No GFEP Equipment Needed At KSC*
    - *I&T Units Could "Follow" Observatory If Requested/Needed/Desired*
    - *Delays Shipment Of Spares Until Post-launch*

Cost



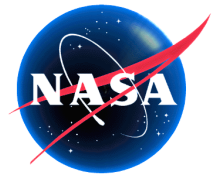
- **WSC equipment**
  - GFEPs (6)
    - $16.5 k each
  - Signal Splitters (2)
    - $4 k each
  - Patch Panels (2)
    - $1.1 k each
  - IFL Electro-Optical Converters (8)
    - $2 k each
  - Network Equipment(4)
    - $1 k each
- **GSFC equipment**
  - Development GFEP
    - $16.5 k
  - Test Environment
    - $16.5 k
- **Development Effort**
  - .5 FTE years
    - $70k
- **WSC Institutional Support**
  - Testing
  - Line Installation & Maintenance
    - $50 k
- **Software Maintenance**
  - After development
    - $3.75 k per month
- **Totals**
  - Non-Recurring (constant dollars)
    - $294 k
  - Recurring (constant dollars)
    - $209 k for 5 years
    - $448 k for 10 years

Open Items



- **ITOS Ability To Perform All Required Control Functions**
- **Our Infrastructure Uncertainty For WSC Installations**
  - *Must Work Closely With WSC To Assure Smooth Installation*
- **Resource Concerns**
  - *Software Development Effort Needs To Be Assessed And Allocated/Assigned Resources*
  - *Test Environment Needs Are Not Funded*
- **KSC Need For GFEP Impact Delivery Schedule Of Spares**
- **Format Of GFEP Signal Connections To I&T Facility**

Road To SDR



- ***Fully Analyze STPS Code Vs. Requirements***
- ***Purchase DEV GFEPs***
- ***Fully Define Test Suite Needs***
- ***Draft Documents***
  - *ICDs*
  - *Ops Agreements*
- ***Enter Docs into CM***
  - *Submit GFEP Requirements To Ground System CCB*
  - *CCR GSRD For GFEP Interfaces*
- ***Deal With Funding Issues***
- ***Obtain Project Buy-off On Plans, Schedules And Funding***
- ***Provide updates at SDR***